Forces and Momentum Test

Name: SOLUTIONS

(45 mins - **Total marks** /~~45~~) /42

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

F =ma

Momentum p = m.v

Impulse I = F.Δt = Δp

Assume that the gravitational field strength is g = 10 N.kg^{-1}.

7

Section A Select the best answer for each question. (1 mark per question) (~~8~~ Marks)

1 A 40 kg child on a scooter is rolling down a footpath at 2.5 m s^{-1}, the momentum of the child is:

A 16 kg m s^{-1} down the footpath.

[✓ B] 100 kg m s^{-1} down the footpath.

C 0.40 kg m s^{-1} down the footpath.

D 42.5 kg m s^{-1} down the footpath.

2 The Law of Conservation of Momentum can be stated as:

A the product of the momentum before the collision is equal to the product of the momentum after.

B the product of the momentum before the collision is always greater than the product of the momentum after.

[✓ C] the sum of the momentum before the collision is equal to the sum of the momentum after.

D momentum can neither be created nor destroyed, it can only change form.

3 In an explosive collision a cannon and a cannonball are initially at rest.

Which of the following options can we **not** be certain about?

A After the collision the momentum of the cannonball added to the momentum of the cannon will equal zero. ✓

[✓ B] The cannonball and the cannon will be moving in the same direction as each other.

C The cannonball will be moving faster than the cannon. ✓

D The momentum of the cannonball and cannon before the collision is zero. ✓

[✓ **4**] A car is travelling north along a road at 8 m s^{-1}. The car turns a corner and keeps travelling at 8 m s^{-1} now travelling towards the west. Which of the following is correct?

A The momentum of the car has changed. ✓

B The speed of the car has changed. ×

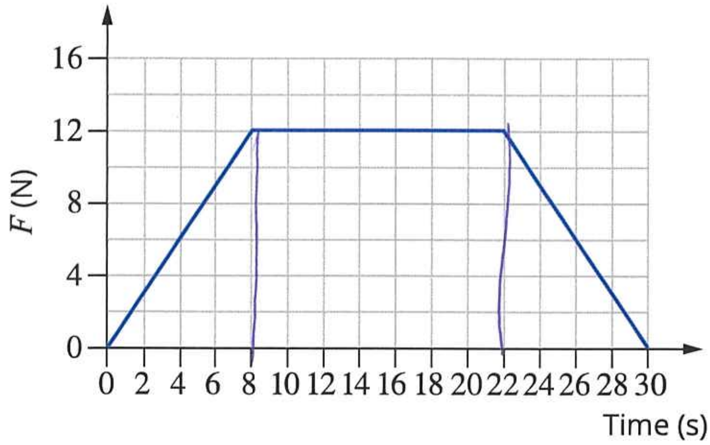
C The velocity has not changed. ×

D The momentum of the car has not changed. ✓

← ↑

The following information applies to questions **5–7**.

The graph shows how a force applied to a stationary 5.0 kg bowling ball varied with time.



5 The total impulse exerted on the bowling ball over the 30 seconds was:

A 456 Ns

B 336 Ns

[✓ **C**] 264 Ns

D 168 Ns

$\frac{1}{\cancel{2}} \times 12 \times \overset{7}{14} + \frac{1}{2} \times 8 \times 12 + \frac{1}{2} \times 8 \times 12.$

$= \overset{168}{\cancel{84}} + 48 + 48 = \overset{168}{96} + 84 = 180$

264

6 The change in momentum of the bowling ball would equal:

A 456 kg m s^{-1}

B 336 kg m s^{-1}

[✓ **C**] 264 kg m s^{-1}

D 168 kg m s^{-1}

7 The final speed of the bowling ball is:

A 12.0 m s^{-1}

B 24.0 m s^{-1}

C 36.8 m s^{-1}

[✓ **D**] 52.8 m s^{-1}

$\Delta p = 264$

$5 \times v = 264$

$v = \frac{264}{5} =$

8 If an object is moving with a constant velocity then according to Newton's first law:

A it will continue with this velocity only if a net external unbalanced force acts. ✗

B it will change its velocity if a net unbalanced external force is applied. ✓

C it will continue with its velocity as no external unbalanced force acts.

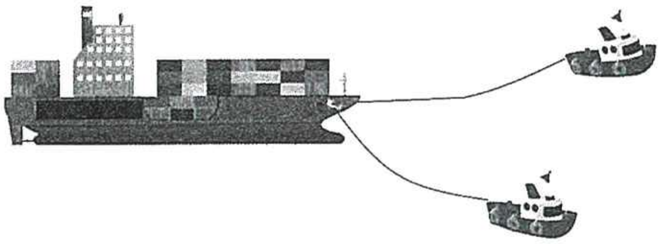
D it will continue with its velocity as friction only acts if an external unbalanced force is applied. ✗

Section B

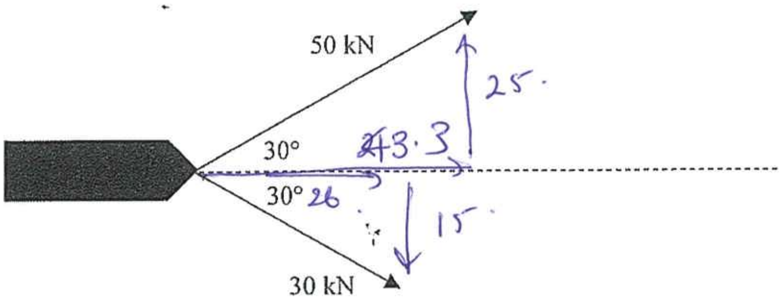
(~~37~~ marks) 35

Q1

A large container ship is being towed into port by two much smaller tug boats. This situation is illustrated in the following diagram.



The forces acting on the ship from the tug boats, when viewed from vertically above, are represented in the diagram below.



a. What are the magnitudes of the forward and sideways components of the 50 kN force?

Forward = 43.3 **kN**

Sideways = 25. **kN**

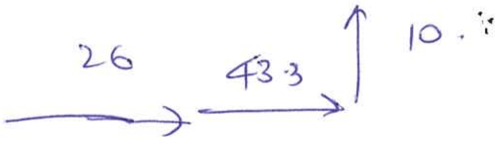
[2 marks]

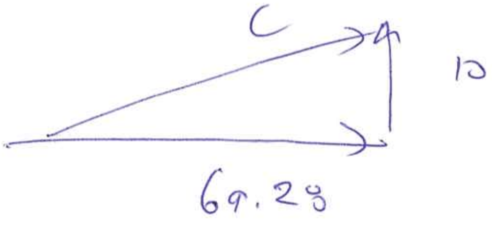
b. What are the magnitudes of the forward and sideways components of the 30 kN force?

Forward = 26 kN	**Sideways =** 15 kN

[2 marks]

c. What is the magnitude of the resultant net force acting on the container ship?





$C = \sqrt{10^2 + 69.28^2}$

$= 70.$

70. kN

[3 marks]

Q2

A car travels safely around a right-hand corner at a constant speed of 60 km h^{-1}. A person seated in the front left-hand passenger seat 'feels' like they are being pushed into the left-hand door as the car turns through the corner.

Explain this person's experience in terms of Newton's first law of motion, applied to the car and the person appropriately. (2 marks)

Due to Newtons First Law the inertia of the person will make them want to continue in a straight line ① As the person is within a car turning to the right it will make them feel like they are being pushed by the left-hand door. ①

Q3

A physics student examines the car she has just bought in order to get to university each day. The car has a mass of 945 kg and is capable of getting from 0 to 60.0 km h^{-1} in 6.50 seconds, and it is painted bright yellow.

$\frac{60}{3.6} = 16.7$ m/s.

a Calculate the acceleration of the car. (2 marks)

$u = 0$, $v = 16.7$ m/s, $t = 6.50$s

$v = \cancel{u}^{0} + at$

$16.7 = a \times 6.5$ $a = \frac{16.7}{6.5} = 2.6$ m/s^2.

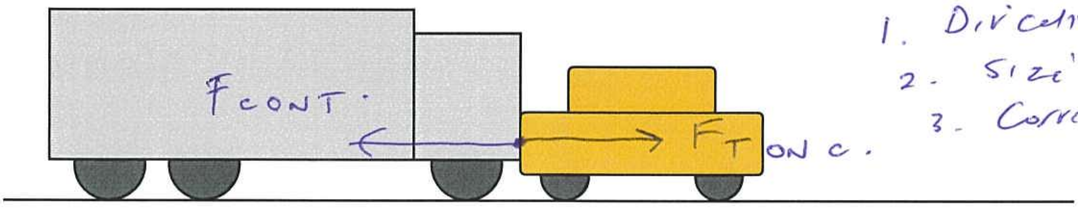
b Calculate the force causing the car to accelerate. 1 (~~2~~ marks)

$\Sigma F = m \times a = 945 \times 2.6 = 2423$ N.

c Calculate the weight of the car. 1 (~~2~~ marks)

$W = m \times g = 945 \times 10 = 9450$ N.

d While she is in class a 5.00 tonne truck collides with her stationary car, which is parked on the side of the road. On the diagram below, use labelled vector arrows to accurately show the forces acting on the truck and on the car. (3 marks)



1. Dircetion
2. Size
3. Correct labels.

Q4 A bike and rider with a mass of 75 kg travelling at 15 ms-1 East when they bump into a 60 kg rollerblader travelling at 5 ms-1 East. The rollerblader moves away from the collision at 20 ms-1 East.

$m_1 = 75$ kg
$u_1 = 15$ m/s $\rightarrow$

$m_2 = 60$ kg
$u_2 = 5$ m/s $\rightarrow$

i Find the change in momentum of the rollerblader.

$\Delta \vec{p} = p_f - p_i$
$= m_2 v_2 - m_2 u_2$
$= 60(20-5) = 60 \times 15 = 900$ kgm/s east ① ①

$m_1 = 75$
$v_1 = ?$ 3m/s

$m_2 = 60$
$v_2 = 20$ m/s $\rightarrow$

ii Find the change in momentum of the bike and the rider.

$\Delta \vec{p}_{roller blader} = \Delta \vec{p}_{bike, rider.}$
(opposite directions)

$\Delta \vec{p}_{bike} = p_f - p_i$
$= 75 \times 3 - 75 \times 15$
$= -900$ kgm/s.
900 kgm/s ① west ①

iii What is the impulse that the rollerblader applies on the bike and rider.

causes $\Delta \vec{p}$ on bike + rider.

$I = -900$ kgm/s

900 kg m/s ①
$\leftarrow$ West. ①

iv Assuming conservation of momentum, find the final velocity of the bike and rider.

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2.$

$75 \times 15 + 60 \times 5 = 75 \times v_1 + 60 \times 20$ ①

$1125 + 300 = 75 v_1 + 1200$

2 + 2 + 2 + 2 marks

$75 v_1 = 1425 - 1200$

$75 v_1 = 225$

$v_1 = \frac{225}{75} = 3$ m/s east. $\rightarrow$
①

deduct ½ mark each time direction ~~not~~

Q5 A car of mass 1000 kg is travelling at a velocity of 15 ms^{-1}. It collides head on against a wall. Calculate the force of impact if it stops in

i 0.5 s

$F \times \Delta t = m \times \Delta v$. ①

$$F = \frac{1000 \times (-15)}{0.5}$$

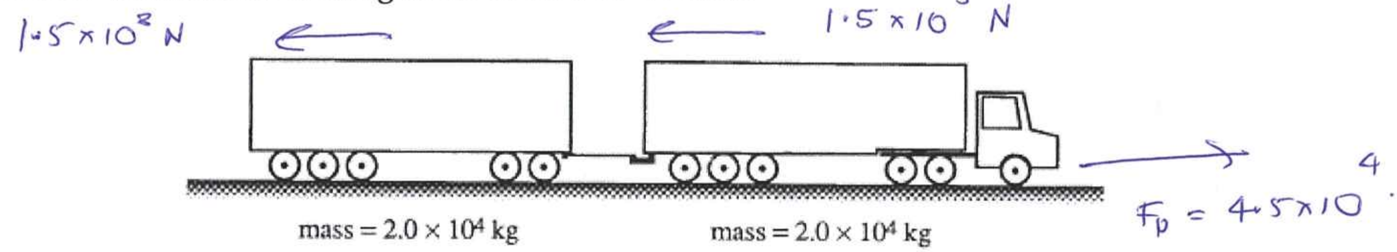
$F = -30\,000$ N   30 000N ①.

ii Explain how 'crumple zones' are used in cars to protect passengers in a crash.

Crumple zones increase the stopping time of impact therefore reduce the force $F = \frac{m \times \Delta v}{\Delta t}$. on the passenger.

2 + 2 marks

A road train consists of a large truck towing a trailer, as shown below. The truck and the trailer have a mass of 2.0 x 10^4 kg each. When moving along a level road, the truck and the trailer experience a **constant retarding force of 1.5 x 10^3 N each.**



Q6
If the driving force on the road train when it is accelerating is 4.5 x 10^4 N, what is the magnitude of the acceleration?

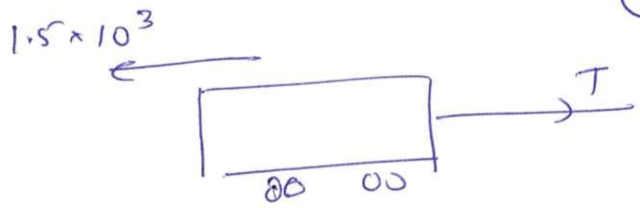
accelerate both masses. ①

$$\Sigma F = (4.5 \times 10^4 - 2 \times 1.5 \times 10^3) = (2 \times 2.0 \times 10^4) \times a.$$

$$a = \frac{42000}{(4 \times 10^4)} = 1.05 \, m/s^2$$ ①.

Q 7

What is the tension force in the coupling between the truck and trailer when the road train is moving at constant speed? $\Sigma F = 0$. ①

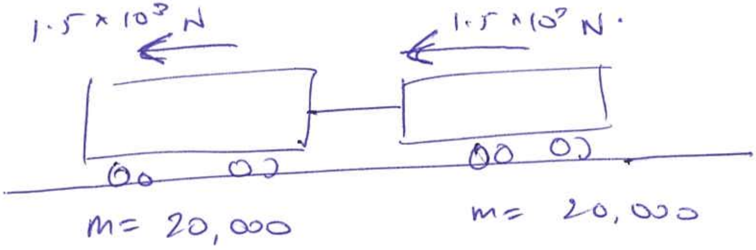


$T = 1.5 \times 10^3$ N $= 1500$N ①.

When the road train is travelling along a straight, level road at 25 m s-1 the truck is put into neutral gear and the train allowed to roll to a stop.

Q 8

How far will it travel before coming to rest?



→ +ve.

decelerate.

2 + 2 + 2 marks

$\Sigma F = m \times a$.

$-3 \times 10^3 = 40,000 \times a$

$a = -\frac{3\cancel{000}}{40\,\cancel{000}} = -0.075$ m/s^2. ①

$u = 25$ m/s. →

$v = 0$.

$v^2 = u^2 + 2as$.

$0 = (25)^2 + 2 \times (-0.075) \times s$. ①.

$s = \frac{25^2}{(2 \times 0.075)} = 4166.7$ m $\approx$ 4200 m